48 subculture generations done till date. Mutation brought about a prominent change in the shape of the sporophores. The two commercial species showed expanded and wide pileuses with an eccentric stipe (Figure 6a and c). The sporeless mutant showed a long, funnel-shaped pileus with a central stipe (Figure 6b). The low-spored mutant showed a highly lobed flower-like pileus with a central stipe (Figure 6d). Another characteristic change brought about due to mutation was the drastic reduction in the number of gills/cm² in the sporeless mutants (Table 2).

The sporeless and low-spored mutants developed during this study have been stable for this character. These mutants will help in mitigating the respiratory allergies among mushroom growers. They can also be used as excellent tools for the genetic understanding of basidiospore formation in mushrooms. The mutants can be further utilized for the commercial production of sporeless strains through genetic manipulation.


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A unique example of a wooden boat of Bridelia retusa in ancient India entrapped in the Holocene sediments at Derde, Ratnagiri Coast, Maharashtra

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Derde is a coastal village in Dapoli taluka, Ratnagiri District, Maharashtra, India. It is located on a small stream 1 km north of and 6 km inland from the mouth of the Vashisht River. A small, completely preserved wooden boat was found in a trench 2 m below the surface. The timber of the boat has been identified as Bridelia retusa Spreng. (trade name – kassi) and belongs to the family Euphorbiaceae. 14C dating showed that the boat belongs to AD 784 ± 102. A study of the geomorphological features of the area combined with aerial photographs revealed that an impulsive hurricane might have resulted in sudden toppling of the boat, sometime around the 8th century. This is a solitary evidence on the use of B. retusa for boat-building in ancient India.

Keywords: Boat-building, Holocene, hurricane, timber.

DERDE (17°36’10”N, 73°12’55”E) is a coastal village in Dapoli taluka, Ratnagiri District, Maharashtra, India (Figure 1). It is located on a small stream (nala) about 1 km north of the Vashisht River and 6 km inland from the coast. The boat was discovered during the excavation of a well in June 2007. The circular trench (Figure 2) had a diameter 4.3 m. The boat was found buried at a depth of 1.9 m from the surface, in an upturned position within a stratum of sand. The boat was 2.6 m high and the exposed bow portion of the boat was about 1.6 m. The stern portion of the boat was engulfed inside the stratum. There were a number of properly preserved wooden planks, 10–13 cm in thickness. It was observed that wooden pegs were used in the construction of the boat; metal nails were absent. About 15 wood samples of the planks were collected. In a preliminary study it was found that all the wood samples were identical. Therefore, one sample was sent for anatomical analysis and for 14C dating.

The study area is surrounded by small hills on three sides and the Vashisht River flows on the southern side. In this area the gradient is very low. In the surrounding area along the small stream there are very thin patches of gravelly deposit.

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Figure 1. Location of map.

The area exhibits typical coastal landforms such as beaches, mudflats, valley floors and highly undulating hills. The lineament along the Vashishti creek towards the inland is a major feature. The major part of the local settlement lies on this lineament. On the valley floor typical Holocene deposition of silt-grade material has occurred. The existence of mudflats, valley floors and fluviatile sediments represents the ongoing depositional activity in the area. The habitation along the lineament confirms the existence of potable water at shallow depths. Good quality groundwater along this lineament was confirmed during the field studies. Existence of groundwater of good quality in ample quantity indicates the maturity of the deposits. Even now, the groundwater is a part of the active tidal activity, i.e. daily rise and fall in water levels or daily change in quality at the time of high and low tide. This demonstrates that the coastal deposits are still very young.

Geologically the site is situated near the area of intersection of the E–W trending straight faulted gorge of the Vashishti River. A small stream originates in the low-lying hills and meets the Vashishti River. About 3 km upstream from the site the Vashishti River has a dendritic drainage pattern. However, the last 3 km of the river shows a contrasting feature, forming a straight course trending E–W, thereby also forming a gorge. Geology of the area consists of Deccan lava flows capped by laterite exposed in isolated patches. The conspicuous presence of a straight gorge trending E–W in contrast to the erosional pattern of drainage east of it is suggestive of the fault along the course of the river. The aerial photograph of this area shows that the site is in close proximity to the mouth of the Vashishti River. Therefore, the site was receptive to demonstrate and replicate the effects of hurricane in the sea. From the top of the trench we found huge boulders of trap and laterite along with lateritic silty gravel, with a thickness of 1.9 m. Underneath this deposit was a properly preserved upturned wooden boat entrapped in a sand deposit. From the top of the boat up to groundwater level, the sand deposit is more than 4 m thick. The
boat was entirely trapped in the sand deposit. Surrounding the boat there were no remnants of either colluvial or alluvial deposits. The boat was 2.6 m high and the exposed bow portion was about 1.6 m. The stern portion of the boat was engulfed inside the stratum. This ascertainsthat due to an intense hurricane the boat was pushed in a small stream with extraordinary pressure and in all probability it overthrew itself when the sea activity was more prominent. This resulted in setting down the boat in a toppled position completely entrapped in the sand. 14C dating confirmed that the timber was as old as AD 784 ± 102 (BS-3002 S-3840) and that sometime around the 8th century an intense hurricane toppled the boat and entrapped it in the sand.

The material used for the anatomical study consisted of small uncarbonized wood pieces. The samples were observed with and without hand lens (10×) to describe the wood, following the methods of Ramesh Rao and Juneja6. Small blocks were made from these samples and boiled in water, and 20 µm sections (cross, CS), tangential longitudinal (TLS) and radial longitudinal (RLS) were cut using Reichert sliding microtome. The sections were stained in haematoxylin, safranin and mounted with DPX mountant. Sections were studied under Leitz Laborlux microscope connected to a Leica QWin Image Analysis system for anatomical characterization and identification. Part of the wood was also converted into chips and macerated for observing individual elements5. Photomicrographs were taken from the Image Analysis System. The specific gravity was determined using mass of the sample at test/oven-dried weight of the sample. For identification of samples, besides authentic slides available at Institute of Wood Science and Technology (IWST), Bangalore, other workers were also referred to7–8.

The wood was brown-coloured, moderately hard and moderately heavy (specific gravity 0.532, oven-dry). The wood was diffuse porous. Growth rings were indistinct to distinct, where distinct was delimited by a fine line of parenchyma. Vessels were visible only under a hand lens, small, moderately numerous, solitary or in radial multiples of 2–3, very rarely up to 4. Parenchyma was scanty paratracheal. Rays were fine to moderately broad, not closely spaced.

Vessels were solitary and in radial multiples of 2–3, rarely up to 4, solitary vessels were oval to angular in outline, filled with dark-coloured gummy deposits, tangential diameter ranged from 85 to 130 µm (average 105 µm). The vessel frequency varied from 7 to 16/mm², vessel element length varied from 148 to 601 µm (average 300 µm) with simple perforations. Inter-vessel pits were alternate, polygonal, small to medium, 5–8 µm (average 6.5 µm) and non-vestured. Vessel ray pitting was horizontal (gash-like) to vertical. Fibres were septate, thin to thick-walled, fibre length varied from 1311 to 1913 µm (average 1612 µm), fibre diameter up to 36 µm (average 30 µm), lumen diameter up to 27 µm (average 20 µm) and inter fibre pits numerous, mostly confined to radial walls. Axial parenchyma was paratracheal, vascentric, consisting of 4–6 cells/strand with prismatic crystals in chambered parenchyma cells, also as delimiting growth rings (marginal band of 2–4 cells). Rays were 1–4 seriate, 5–8/mm, heterocellular, composed of procumbent cells with mostly 1–2 rows of upright and/or square marginal cells. Ray height varied from 502 to 1766 µm (average 1125 µm or 50-plus cells). Prismatic crystals were occasionally observed in procumbent and upright cells. Perforated ray cells were not observed (Figure 3). Except for dark-coloured inclusions in fibres, no fungal attack was observed indicating soundness of the wood.

The card key features were – 2, 5, 10, 12, 13, 22, 23, 25, 32, 42, 47, 65, 69, 72, 79, 89, 93, 97, 102, 115, 137?, 138?, 141, 169, 189, 192, 194, 197.

Based on the distribution of the vessels, parenchyma type and nature of ray and septate fibres, the sample has been identified as Bredelia Wild., probably Bredelia retusa Spreng. (trade name – kassi) and belongs to the family Euphorbiaceae.

The timber of B. retusa has been used in the construction of the boat. This species is distributed across many parts of India, including Maharashtra8,9. Information on properties and uses of the wood showed that the timber has the characteristic of being notably durable even when in contact with water. Although the timber is recommended for making agricultural implements, carts, cart shafts, yokes and drums, posts, rafters, poles, baulks and cross arms, tool handles, packing cases, mine work, dunnage pallet, railway sleeper, flooring, ceiling, furniture and cabinet-making10, no information is available regarding its use in boat-building. The people of the Holocene period may have been aware of its durability and hence used it in the construction of small boats.

The western coast of India remains little explored by nautical archaeologists and ethnographers. Perhaps the best-known traditional boat-building can be traced back to the late second millennium bc11. However, on the west coast of India, this is the only instance of using B. retusa in boat-building in ancient times. 14C dating confirmed that the wood belonged to AD 784 ± 102. This showed that Holocene man was aware of the durability of this timber, especially when in contact with water. The field studies demonstrate that sometime around the 8th century due to an intense hurricane the boat was pushed in a small stream with extraordinary pressure and in all probability overthrew itself when the sea activity was more prominent. This resulted in resetting the boat in a toppled position completely entrapped in the sand.

While putting together the final draft of this communication, the cyclone Phyan passed the Mumbai and Konkan coastline on 11 November 2009 evening. A major catastrophe was averted as the cyclone Phyan, with a wind speed of 85 km/h, weakened into a tropical storm. It did, however, claim lives and property in the coastal
districts of Thane, Mumbai, Raigad, Ratnagiri and Sindhudurg in Maharashtra. A field trip was arranged to study the aftermath of the cyclone in the area comprising Balapur, Derde and Bhojwada around Dahhol. It was found that eight fishing boats had gone missing, one large fishing trawler had sunk in the rough seas and seven fishermen had lost their lives in this tragedy. Three fishing boats had moved in a small stream and another boat had toppled over completely. These observations carried out in the same area post-cyclone Phyan fully substantiate the above-mentioned reconstruction of the 8th century event.


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